I – Problem Statement Title (027)

Development of Precast Columns and Beam Systems for Rapid Construction of Bridges in Seismically Active Regions

II – Research Problem Statement

Question: How can precast bridge columns and beams be designed such that they are durable, economical to build, minimize traffic disruption and perform well during strong earthquake motions?

An important drawback of traditional cast-in-place construction is the need for numerous and time-consuming construction operations that must be performed on site. Construction of falsework, construction of formwork, reinforcement placement, concrete casting, concrete curing, and formwork removal all slow construction and can disrupt traffic on a bridge or below it. Environmental considerations can also reduce the attractiveness of using cast-in-place reinforced concrete. For example, leakage of wet concrete into waterways is not usually allowed, and even temporary falsework can impede or harm migrating fish.

In non-seismic regions, precast columns and beams have been used successfully to reduce the traffic delays and environmental impacts resulting from bridge construction. In contrast, precast substructure systems have seldom been used in seismic regions. The high amount of reinforcement required in beam-column joints in seismic regions, which lead to constructability challenges in cast-in-place concrete, can become even more challenging in precast structures.

The challenge here is to develop and evaluate precast systems that are fast and easy to erect, and have the needed seismic performance and long-term durability.

III – Objective

STAP Roadmap Outcome: 3. Reduce the Impact of Structure Construction and Maintenance Activities on the Traveling Public.

The objective of this research is to develop and test precast concrete column-beam systems that are fast to construct, perform well during earthquakes and durable.

IV – Background

For buildings, a similar challenge was faced and overcome in the PRESSS program, during which successful, new systems were developed, specifications were written and adopted by the American Concrete Institute (ITG 1.1). The systems have been used in new buildings in California. The building development effort has provided valuable lessons on the development of precast systems in seismic zones

The research should also benefit from parallel research sponsored by the Washington State Department of Transportation in this same area.

- Hieber, D.G., Wacker, J.M., Eberhard, M.O. and Stanton, J.F., "State-of-the-Art Report on Precast Concrete Systems for Rapid Construction of Bridges," Washington State Department of Transportation Report WA-RD 594.1, Olympia, Washington, March 2005, 112 pp.
- Hieber, D.G., Wacker, J.M., Eberhard, M.O. and Stanton, J.F., "Precast Concrete Pier Systems for Rapid Construction of Bridges in Seismic Regions," Washington State Department of Transportation Report WA-RD 611.1, Olympia, Washington, March 2005, 312 pp.
- Stanton, J., Eberhard, M., Gunnarssion, K., Hieber, D. and Wacker, J., "Rapid Construction Details for Bridges in Seismic Zones," Proceedings, 8th U.S. National Conference on Earthquake Engineering, San Francisco, California, April 2006 (submitted for review).

Potential for success of precast, prestressed columns as part of the energy dissipation system for a bridge subjected to severe earthquake excitations is suggested by recent and on-going research sponsored by the Pacific Earthquake Engineering Research Center related to partially prestressed, reinforced concrete columns havng unbonded post-tensioning and mild reinforcement

- Mahin, S., Sakai, J., Jeong, H., Espinoza, A., Hachem, M. and Buckman, B, "Shake Table and Analytical Investigations of Single Column Bents," Proceedings, Caltrans Seismic Research Workshop, Sacramento, Oct.-Nov. 2005.
- Sakai, J. and Mahin, S. A. (2004a). "Analytical investigations of new methods for reducing residual displacements of reinforced concrete bridge columns." *PEER-2004/02*, Pacific Earthq. Engrg. Res. Center, Univ. of California at Berkeley, California.

V – Statement of Urgency, Benefits, and Expected Return on Investment

In comparison with traditional cast-in-place construction, precast concrete bridge components offer the potential to:

- facilitate rapid construction,
- minimize traffic disruption,
- improve work zone safety,
- reduce environmental impacts,
- improve constructability,
- reduce residual displacements following earthquakes,
- and lower life-cycle costs.

These benefits to Caltrans and the public can only be realized if constructible details are developed that also have good seismic performance. As traffic congestion, construction costs and environmental constraints continue to increase, the urgency of developing these systems will continue to increase also.

VI – Related Research

- WSDOT-sponsored research at U. of Washington from 2003-2005 and planned for 2006-2007 (Stanton and Eberhard).
- Caltrans-sponsored research at U.C. Berkeley (Mahin)
- NCHRP-sponsored research at UCSD and Sacramento State

VII – Deployment Potential

As a result of this research, new structural systems will have been developed and evaluated for ease of constructibility, durability and seismic performance. These systems could first be used in situations in which traffic disruption is a key design consideration. As contractors gain experience in constructing these systems, construction costs will likely decrease and these systems could be used for many bridges.